Grant Final Report

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Title: "Assessment of Climatic and Anthropogenic Impacts on the Global Carbon Cycle Constrained by Atmospheric Measurements and Remote Sensing Data".

1. Aims

This grant aimed to establish how the global carbon cycle has responded and will respond to global change. We proposed to use models to predict measurements of atmospheric CO_2 concentration and $^{13}C/^{12}C$ isotopic ratio, and thereby to establish how sources and sinks of atmospheric CO_2 have been influenced by climatic change and human activities. As the work progressed we developed strategies involving finding regional sources and sinks of atmospheric CO_2 by an inverse approach, and studying their seasonal and interannual variability. The work was coordinated with NASA Grant NAG5-3528 at the University of Montana under the direction of Steven Running and NASA Grant NAG5-3861 at the University of Wyoming under the direction of E. Raymond Hunt, Jr.

2. Results

We carried out a detailed analysis of global and regional terrestrial sources and sinks of the terrestrial biosphere reported in documents listed below [Keeling et al., 2000; Piper et al., 2000a,b; and Keeling and Piper, 2000], based on 22 years of direct measurements of the concentration and $^{13}C/^{12}C$ ratio of atmospheric CO_2 and on 13 years of satellite-borne radiometric data from which we derived net primary productivity via a normalized-difference vegetative index (NDVI). We further analyzed the relations of these sources and sinks of atmospheric CO_2 to climatic factors especially with respect to seasonal variability [Myneni et al., 1997, 1998]. Major findings are noted in the Third Assessment Report of the IPCC [Prentice et al., 2001].

Our determination of sources and sinks of atmospheric CO_2 made use of an atmospheric tracer transport model from which we deduced CO_2 exchange fluxes by an inverse technique, as reported, but we also used this model to predict atmospheric CO_2 based on outputs of a terrestrial biospheric process model, BIOME-BGC. These model simulations of CO_2 fluxes were supplied to us by Dr. Peter Thornton and Professor Steven Running of the Forestry Department, University of Montana. Their model was substantially different from that used in our previous process studies [Hunt et al., 1996], and more work is needed before the results are submitted for publication.

3. Publications

1. Myneni, R. B., C. D. Keeling, C. J. Tucker, G. Asrar, and R. R. Nemani, "Increased plant growth in the northern high latitudes from 1981 to 1991," *Nature, 386*, 698-702, 1997.
2. Myneni, R. B., C. J. Tucker, G. Asrar, and C. D. Keeling "Interannual variations in satellite-sensed vegetation index data from 1981 to 1991," *Journal of Geophysical Research, 103*, 6145-6160, 1998.
3. Keeling, C. D., S. C. Piper, R. B. Bacastow, M. Wahlen, T. P. Whorf, M. Heimann, and H. A. Meijer, "Exchanges of atmospheric CO_2 and $^{13}CO_2$ with the terrestrial biosphere and oceans from 1978 to 2000. I. Global aspects," SIO Reference Series, No. 00-21, Scripps Institution of Oceanography, San Diego, 88 pages, December, 2000.
4. Piper, S. C., C. D. Keeling, M. Heimann, E. F. Stewart, "Exchanges of atmospheric CO_2 and $^{13}CO_2$ with the terrestrial biosphere and oceans from 1978 to 2000. II. A three-dimensional tracer inversion model to deduce regional fluxes," SIO Reference Series, No. 00-22, Scripps Institution of Oceanography, San Diego, 56 pages, December, 2000.
5. Piper, S. C., C. D. Keeling, E. F. Stewart, "Exchanges of atmospheric CO_2 and $^{13}CO_2$ with the terrestrial biosphere and oceans from 1978 to 2000. III. Sensitivity test," SIO Reference Series, No. 00-23, Scripps Institution of Oceanography, San Diego, 80 pages, December, 2000.
6. Keeling, C. D., and S. C. Piper, "Exchanges of atmospheric CO_2 and $^{13}CO_2$ with the terrestrial biosphere and oceans from 1978 to 2000. IV. Critical overview," SIO Reference Series, No. 00-24, Scripps Institution of Oceanography, San Diego, 67 pages, December, 2000.

Other Publications Cited

1. Hunt, E. R., Jr., S. C. Piper, R. Nemani, C. D. Keeling, R. D. Otto, and S. W. Running, "Global net carbon exchange and intra-annual atmospheric CO_2 concentrations predicted by an ecosystem process model and three-dimensional atmospheric transport model," *Global Biogeochemical Cycles, 10*, 431-456, 1996.
2. Prentice, I. C., et al., Chapter 3. The Carbon Cycle and Atmospheric CO_2, Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), 2001.